

CLAIMS

1. A boron phosphide-based semiconductor light-emitting device, comprising:

5 a crystalline substrate;

a first semiconductor formed on said crystalline substrate, said first semiconductor layer including a light-emitting layer, serving as a base layer and having a first region and a second region different from the first region;

10 a boron phosphide-based semiconductor amorphous layer formed on said first region of said first semiconductor layer, said boron phosphide-based semiconductor amorphous layer including a high-resistance boron phosphide-based semiconductor amorphous layer;

15 a pad electrode formed on said high-resistance boron phosphide-based semiconductor amorphous layer for establishing wire bonding; and

20 a conductive boron phosphide-based crystalline layer formed on said second region of said first semiconductor layer, said conductive boron phosphide-based crystalline layer extending optionally to a portion of said boron phosphide-based semiconductor amorphous layer,

25 wherein said pad electrode is in contact with said boron phosphide-based semiconductor crystalline layer at a portion of said pad electrode above the bottom of said pad electrode.

2. A boron phosphide-based semiconductor light-emitting device, comprising:

30 a crystalline substrate;

a first semiconductor layer formed on said crystalline substrate, said first semiconductor layer including a light-emitting layer, serving as a base layer and having a first region and a second region different from said first region;

35 a boron phosphide-based semiconductor amorphous layer formed on said first region of said first

5           semiconductor layer, said boron phosphide-based semiconductor amorphous layer including a first boron phosphide-based semiconductor amorphous layer having a conduction type opposite to that of said first semiconductor layer;

10           a pad electrode formed on said first boron phosphide-based semiconductor amorphous layer, for establishing wire bonding; and

15           a conductive boron phosphide-based crystalline layer formed on said second region of said first semiconductor layer, said conductive boron phosphide-based crystalline layer extending optionally to a portion of said boron phosphide-based semiconductor amorphous layer,

20           wherein said pad electrode is in contact with said boron phosphide-based semiconductor crystalline layer at a portion of said pad electrode above the bottom of said pad electrode.

25           3. A boron phosphide-based semiconductor light-emitting device as set forth in claim 1 or 2, wherein said boron phosphide-based semiconductor amorphous layer has a multilayer structure formed from a boron phosphide-based semiconductor amorphous layer which is formed so as to attain contact with said first semiconductor layer and which is of a conduction type opposite to that of said first semiconductor layer, and a high-resistance boron phosphide-based semiconductor amorphous layer formed on said boron phosphide-based semiconductor amorphous layer having said opposite conduction type.

30           30. 4. A boron phosphide-based semiconductor light-emitting device as set forth in any one of claims 1 to 3, wherein said boron phosphide-based semiconductor amorphous layer is formed of an undoped boron phosphide-based semiconductor.

35           35. 5. A boron phosphide-based semiconductor light-emitting device as set forth in claim 3, wherein the two boron phosphide-based semiconductor amorphous layers

constituting the multilayer structure of said boron phosphide-based semiconductor amorphous layer are formed of an undoped boron phosphide-based semiconductor.

6. A boron phosphide-based semiconductor light-emitting device as set forth in any one of claims 1 to 5, wherein said portion of the pad electrode in contact with said conductive boron phosphide-based semiconductor crystalline layer is formed of a material able to form an Ohmic contact with the conductive boron phosphide-based crystalline layer.

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1. A boron phosphide-based semiconductor light-emitting device as set forth in claim 6, wherein said portion of the pad electrode formed of a material able to form Ohmic contact with the conductive boron phosphide-based crystalline layer extends onto said conductive boron phosphide-based semiconductor crystalline layer.

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2. A boron phosphide-based semiconductor light-emitting device as set forth in claim 6 or 7, wherein said pad electrode has a bottom portion formed of a material able to form non-Ohmic contact with said boron phosphide-based semiconductor amorphous layer.

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3. A boron phosphide-based semiconductor light-emitting device as set for the in any one of claims 1 to 8, wherein said pad electrode has a bottom portion provided on said boron phosphide-based semiconductor amorphous layer, and an Ohmic electrode portion which is provided on the bottom portion and which has a center coincident with that of the plane shape of the bottom portion.

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4. A boron phosphide-based semiconductor light-emitting device as set forth in claim 9, wherein said Ohmic electrode portion of said pad electrode has a planar area greater than that of the bottom portion of said pad electrode.

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5. A boron phosphide-based semiconductor light-emitting device as set forth in claim 10, wherein said Ohmic electrode portion of said pad electrode extends

onto a surface of said conductive boron phosphide-based semiconductor crystalline layer.

12. A boron phosphide-based semiconductor light-emitting device as set forth in any one of claims 1 and 3 to 11, wherein said high-resistance boron phosphide-based semiconductor amorphous layer has a resistivity of 10  $\Omega \cdot \text{cm}$  or more.

13. A boron phosphide-based semiconductor light-emitting device as set forth in claim 12, wherein said high-resistance boron phosphide-based semiconductor amorphous layer has a resistivity of 100  $\Omega \cdot \text{cm}$  or more.

14. A boron phosphide-based semiconductor light-emitting device as set forth in any one of claims 1 to 13, wherein said boron phosphide-based semiconductor is selected from the group consisting of  $B_\alpha Al_\beta Ga_\gamma In_{1-\alpha-\beta-\gamma} P_{1-\delta} As_\delta$  ( $0 < \alpha \leq 1$ ,  $0 \leq \beta < 1$ ,  $0 \leq \gamma < 1$ ,  $0 < \alpha + \beta + \gamma \leq 1$ ,  $0 \leq \delta < 1$ ) and  $B_\alpha Al_\beta Ga_\gamma In_{1-\alpha-\beta-\gamma} P_{1-\delta} N_\delta$  ( $0 < \alpha \leq 1$ ,  $0 \leq \beta < 1$ ,  $0 \leq \gamma < 1$ ,  $0 < \alpha + \beta + \gamma \leq 1$ ,  $0 \leq \delta < 1$ ).

15. A boron phosphide-based semiconductor light-emitting device as set forth in any one of claims 1 to 13, wherein said boron phosphide-based semiconductor is selected from the group consisting of boron monophosphide (BP), boron gallium indium phosphide (compositional formula:  $B_\alpha Ga_\gamma In_{1-\alpha-\gamma} P$ :  $0 < \alpha \leq 1$ ,  $0 \leq \gamma < 1$ ), or a mixed-crystal compound of boron nitride phosphide (compositional formula:  $BP_{1-\delta} N_\delta$ :  $0 \leq \delta < 1$ ) or boron arsenide phosphide (compositional formula:  $B_\alpha P_{1-\delta} As_\delta$ :  $0 \leq \delta < 1$ ).

16. A boron phosphide-based semiconductor light-emitting device as set forth in claim 6, wherein said conductive boron phosphide-based crystalline layer is a p-type conductivity layer and said portion of said pad electrode in contact with said conductive boron phosphide-based crystalline layer is selected from the

group consisting of Au-Zn and Au-Be.

17. A boron phosphide-based semiconductor light-emitting device as set forth in claim 6, wherein said conductive boron phosphide-based crystalline layer is an n-type conductivity layer and said portion of said pad electrode in contact with said conductive boron phosphide-based crystalline layer is selected from the group consisting of Au-Ge, Au-Sn and Au-In.

18. A boron phosphide-based semiconductor light-emitting device as set forth in claim 8, wherein said boron phosphide-based amorphous layer is a p-type conductivity layer and said portion of said pad electrode in contact with said conductive boron phosphide-based crystalline layer is selected from the group consisting of Au-Ge, Au-Sn, Au-In, Ti, Mo, V, Ta, Hf and W.

19. A boron phosphide-based semiconductor light-emitting device as set forth in claim 8, wherein said boron phosphide-based amorphous layer is a p-type conductivity layer and said portion of said pad electrode in contact with said conductive boron phosphide-based crystalline layer is selected from the group consisting of Au-Zn, Au-Be, Au-In, Ti, Mo, V, Ta, Hf and W.

20. A method for producing a boron phosphide-based semiconductor light-emitting device, comprising:

25 forming a first semiconductor layer including a light-emitting layer on a crystalline substrate through vapor phase growth;

30 depositing, through vapor phase growth employing said first semiconductor layer serving as a base layer at a crystalline substrate temperature falling within a range of 250°C to 1,200°C, a boron phosphide-based semiconductor amorphous layer having high resistance or a boron phosphide-based semiconductor amorphous layer having a conduction type opposite to that of the base layer;

35 selectively removing said boron phosphide-based semiconductor amorphous layer, thereby causing said

boron phosphide-based semiconductor amorphous layer to remain in a first region and exposing said first semiconductor layer in a second region different from the first region;

5           depositing a conductive boron phosphide-based semiconductor crystalline layer on said exposed first semiconductor layer and said boron phosphide-based semiconductor amorphous layer through vapor phase growth at a crystalline substrate temperature falling within a range of 750°C to 1,200°C;

10           selectively removing said conductive boron phosphide-based semiconductor crystalline layer in said first region, thereby exposing said boron phosphide-based semiconductor amorphous layer;

15           forming a pad electrode for establishing wire bonding on said exposed boron phosphide-based semiconductor amorphous layer such that said pad electrode is caused to be in contact with said boron phosphide crystalline layer; and subsequently,

20           cutting said formed structure, to thereby produce individual light-emitting devices.

21. A method for producing a boron phosphide-based semiconductor light-emitting device as set forth in claim 20, further comprising removing said conductive boron phosphide-based semiconductor crystalline layer present in said first region where said pad electrode is to be provided and simultaneously, removing said conductive boron phosphide-based semiconductor crystalline layer present in a region where a stripe-like dicing line for cutting and separating said structure into individual light-emitting devices is provided, thereby exposing a surface of the underlying boron phosphide-based semiconductor amorphous layer.